PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : A01G 9/02, 31/02 — A1

(11) International Publication Number: WO 94/13129

(43) International Publication Date: 23 June 1994 (23.06.94)

(21) International Application Number: PCT/AU93/00641

(22) International Filing Date: 13 December 1993 (13.12.93)

(30) Priority Data:
30046/92 11 December 1992 (11.12.92) AU

(71) Applicant *(for all designated States except US)*: MYTOL PTY. LIMITED [AU/AU]; 18 Wilson Street, Kiama, NSW 2533 (AU).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: DODD, Norman [US/AU]; 18 Wilson Street, Kiama, NSW 2533 (AU).

(74) Agents: HALFORD, Graham, William et al.; Halford & Co., 1 Market Street, Sydney, NSW 2000 (AU).

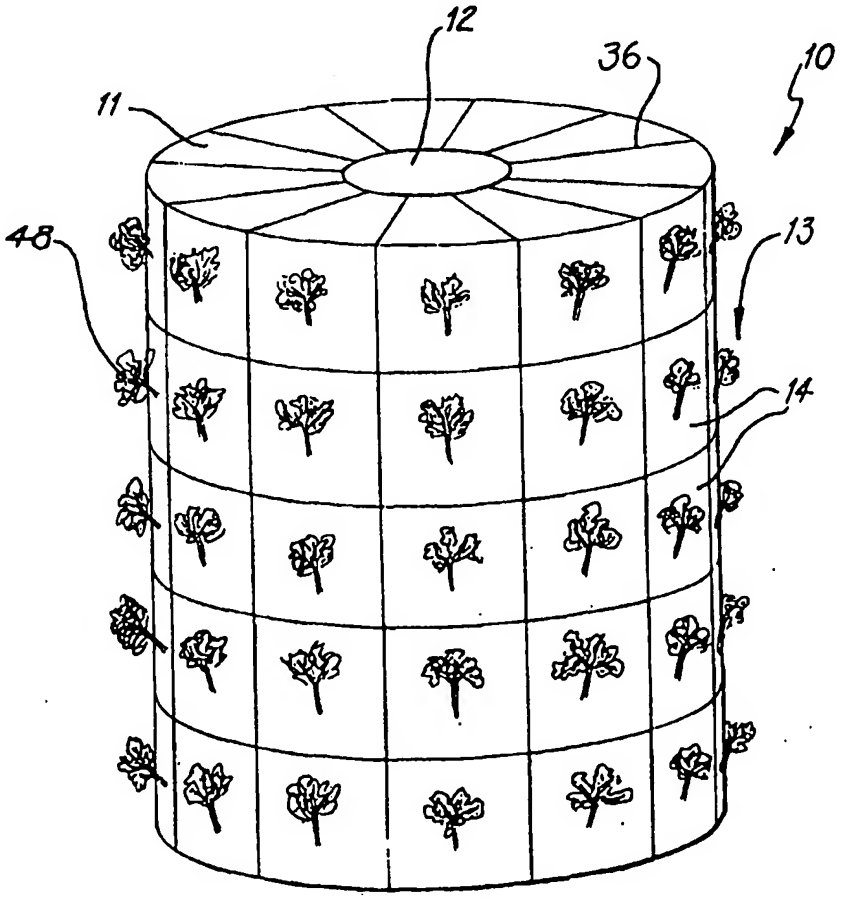
(81) Designated States: AT, AU, BB, BG, BR, BY, CA, CH, CZ, DE, DK, ES, FI, GB, HU, JP, KP, KR, KZ, LK, LU, LV, MG, MN, MW, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SK, UA, US, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: PLANT GROWING APPARATUS AND PROCESS

(57) Abstract

An apparatus is disclosed for the controlled growth of a plurality of plants, defining three plant husbandry zones into which each plant is divided. A first zone (11) comprising an upright array of compartments (14) provides stability and control of a long-life plant mass of the plants and allows acess to the plant mass therein. Second (13) and third (12) zones contain harvestable foliage and harvestable roots respectively of the plants, allowing harvesting of harvestable foliage and root mass and regeneration of the harvestable foliage and root mass from the long-life plant mass in the first zone. A process for the growth, husbandry and harvesting of plants and a root anchor structure are also disclosed.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**GB**	United Kingdom	**MR**	Mauritania
AU	Australia	**GE**	Georgia	**MW**	Malawi
BB	Barbados	**GN**	Guinea	**NE**	Niger
BE	Belgium	**GR**	Greece	**NL**	Netherlands
BF	Burkina Faso	**HU**	Hungary	**NO**	Norway
BG	Bulgaria	**IE**	Ireland	**NZ**	New Zealand
BJ	Benin	**IT**	Italy	**PL**	Poland
BR	Brazil	**JP**	Japan	**PT**	Portugal
BY	Belarus	**KE**	Kenya	**RO**	Romania
CA	Canada	**KG**	Kyrgystan	**RU**	Russian Federation
CF	Central African Republic	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CG	Congo			**SE**	Sweden
CH	Switzerland	**KR**	Republic of Korea	**SI**	Slovenia
CI	Côte d'Ivoire	**KZ**	Kazakhstan	**SK**	Slovakia
CM	Cameroon	**LI**	Liechtenstein	**SN**	Senegal
CN	China	**LK**	Sri Lanka	**TD**	Chad
CS	Czechoslovakia	**LU**	Luxembourg	**TG**	Togo
CZ	Czech Republic	**LV**	Latvia	**TJ**	Tajikistan
DE	Germany	**MC**	Monaco	**TT**	Trinidad and Tobago
DK	Denmark	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**US**	United States of America
FI	Finland	**ML**	Mali	**UZ**	Uzbekistan
FR	France	**MN**	Mongolia	**VN**	Viet Nam
GA	Gabon				

PLANT GROWING APPARATUS AND PROCESS

BACKGROUND OF INVENTION

The present invention relates to an improved apparatus for growing plants, and a process which provides the controlled growth, husbandry and harvesting of plants, through management and control over an accessible part of the root mass.

SUMMARY OF INVENTION

The invention aims to allow the simultaneous hydroponic growth, husbandry and harvesting of a large number of plants in an efficient manner.

In one form, the invention provides a plant growing apparatus adapted for control of the growth, feeding, treatment and environment of and the simultaneuous husbandry of a plurality of plants, comprising an upright structure which defines three plant husbandry zones into which each plant is divided:

a first plant husbandry zone for providing stability and control of a long-life plant mass of said plants, comprising an upright array of compartments each adapted to contain the long-life plant mass of a plant, said compartments allowing access to the plant mass therein,

a second plant husbandry zone located externally to said compartments for the growth and husbandry of harvestable foliage communicating with the long-life plant mass; and

a third plant husbandry zone located externally to said compartments for the growth and husbandry of harvestable root mass communicating with the long-life plant mass; and

means for applying plant husbandry fluids to the plant mass in at least the first zone;

the apparatus allowing harvesting of the harvestable foliage and harvestable root mass of the plants and regeneration of harvestable foliage and root mass in the second and third zones from the long-life plant mass.

Preferably, the second zone extends outwardly, from an outer wall surface of the structure. The first zone is preferably between the second zone and the third zone, with the compartments being elongated in the direction from the second zone to the third zone. In one preferred form, the compartments are tapered inwardly from the second zone-end to the third zone-end.

The apparatus is preferably constructed by the interengagement of multiple vertical or horizontal rows of the compartments. The apparatus may comprise a wall of such compartments, with the second zone at one side of the wall and the third zone at the other. However, in one particularly preferred form, the third zone is inside the apparatus. For example, the apparatus may consist of two parallel walls with the space between the walls forming the third zone. Desirably, the wall forms a tower, preferably cylindrical, with the third zone being a central cavity within the tower and the compartments extending radially outwards to the second zone about the outer surface of the tower.

In a further form, the invention provides a method for the growth, husbandry and harvesting of plants, comprising;

growing a long-life root mass of a plurality of plants in an upright array of compartments defining a first

plant husbandry zone, each compartment providing at least partial stability and access to an exposed portion of the long-life plant mass therein,

applying plant husbandry fluid to the compartments,

growing harvestable foliage of said plants outwardly from the compartments in a second plant husbandry zone,

growing a foliage-remote harvestable end of the root mass in a third plant husbandry zone,

harvesting the foliage in the second zone and/or the root mass in the third zone while retaining the long-life plant mass in the compartments, and

allowing regeneration of the harvestable foliage and/or the harvestable root mass from the long-life plant mass.

In a yet further form of the invention there is provided a plant container having root anchor means as described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

Further preferred embodiments of the invention shall now be discussed with reference to the accompanying drawings, in which:

Fig. 1 is a schematic perspective view of a tower arrangement with the top cut away;

Fig. 2 is a side view of a compartment of the tower, with the side wall cut away;

Fig. 3 is a cross sectional view of the compartment of Fig. 2, taken along a line normal to a radius of the tower, showing the interengagement with adjacent compartments;

Fig. 4 is an elevation of a preferred means for providing plant husbandry fluid to the third zone;

Fig. 5 is a plan view of an alternative embodiment, in which a number of compartments are formed together.

Fig. 6 is a schematic perspective view of a wall arrangement according to a further embodiment;

Fig. 7 is a plan view of a multiple compartment tray for forming the wall of Fig. 6;

Fig. 7A is a plan view of a variation of the multiple compartment tray of Fig. 7;

Fig. 8 is a schematic front cross-section view of a yet further embodiment, in which the apparatus is of flexible construction;

Fig. 9 is a side view of a compartment in the apparatus of Fig. 8; and

Fig. 10 is a plan view of a variation on the construction of Figs. 8 and 9.

DETAILED DESCRIPTION OF THE DRAWINGS

With reference to Fig. 1, the tower 10 generally consists of an annular first root zone 11, a third zone 12 formed as a central cavity extending down through the tower, and a second zone 13 extending outwardly from the periphery of the tower.

The first zone is divided into vertical and horizontal rows of radial compartments 14, each adapted to grow a plant 48. Adjacent compartments are divided by walls 36. Although only a relatively small number of large compartments are shown in this schematic drawing, it will be appreciated that the compartments are in practice quite narrow, for example about 10-50mm wide, and about 20-70mm high, and the tower will have a large number of compartments, usually from about 100 to 100 000, for the simultaneous growth of many plants. The size and shape of the compartments may be varied according to the type of plant root system to be accommodated. It is preferred that the plants grown in the tower be twin plants produced by cloning superior plants produced from seeds, naturally occuring plants which do not breed true and genetically altered plants. This, combined with rotation of the tower about its longitudinal axis to equalise the tower's plant growth environment and conditions, should result in substantially identical plants and growth rates so that the plants can be managed to reach maturity together for efficient harvesting.

The top of the tower is closed with a removable lid (not shown) with a central hole to allow access to the roots grown in the third zone for direct husbandry of and, in particular, harvesting of these roots. The bottom of the tower has a base (not shown) which may have an access opening in its side to allow access to the bottom of the central cavity. The lid and base allow rotation of the tower, and may be attached by rods which extend up through the tower for stability.

Referring now to Figs. 2 and 3, which show the compartments in more detail, it can be seen that each

compartment 14 has top 15 and bottom 16 sections which fit together to form an enclosure for the plant roots. The compartments may be removed from the tower and opened to allow access to the roots within and reinserted or replaced without interrupting the husbandry of the remaining plants in the tower. The access allows direct husbandry upon the plant without damage to the roots thereof. The compartments are generally wedge shaped in plan view, and have top and bottom male 17a, 17b and female 18a, 18b flanges along their radial edges for engaging the flanges of similar compartments, as shown in Fig. 3. The tower is constructed of horizontal rows of such compartments, each row consisting of a large number of engaged compartments.

As best seen in Fig. 2 each compartment has a foliage exit aperture 19 in the top section 15 adjacent the outermost end of the compartment for the growth of foliage outwardly from the tower. This aperture lies above a planting ramp 20, on the bottom of which the root crown or apex of the plant is situated. The roots of the plant grow radially inwardly towards the root exit aperture 21 formed in the bottom section 16 at the innermost end of the compartment, down the root ramp 22 of the compartment below and into the central cavity 12 of the tower. The elongated, inwardly tapered compartment, with its small root exit influences the type of root growth in the first zone, limiting the number of fibrous side branches formed in the roots in that zone. The roots in the central cavity grow suspended in air. If the roots in the first zone only are fed with nutrient fluids, the roots in the third zone will consist of a limited number of air roots. However, if the roots in the third zone are fed, the plants will grow a significant number of the aeroponic roots into this zone.

According to one aspect of the invention, there is provided root anchoring means for providing plant stability, which eliminates the need for external supports or media such as sand or plastic granules as used in conventional hydroponic arrangements. The root anchor means is preferably situated within the compartment, but may be positioned between the first and third zones. The root anchor means comprises a structure having spaced apart members between which the roots are retained. Alternatively, the roots can be retained between the members and the walls of the compartment.

With reference to Figs. 2 and 3, the root anchors 23 consist of a series of fingers 24 extending downwardly across the direction of root growth, between which the roots grow. Preferably, the anchors comprise a plurality of rows of fingers in a staggered arrangement so that the roots intertwine between the fingers to provide plant stability.

As shown, the fingers 24 may conveniently be formed as part of the top section of the compartment, but in some configurations it may be more economical to insert the root anchors in the compartments.

In use, the root mass initially grows in the narrow region of the compartment between funnels 25 (the function of which will be described below) and may eventually become wedged in that region to provide some initial plant stability. As the roots continue to grow inwardly, they intertwine with the root anchors to give further stability to the plant. Removal of the plant from the compartment is easily achieved by removing the compartment from the tower, separating the top 15 and bottom 16 sections and

lifting the roots away from the root anchors. This allows the plant mass within the compartments to be used as human or animal feed without contamination by a medium, and also allows access to the first zone plant mass for trimming of the root or replacement with another plant. The compartment and root anchors can be sterilised for re-use without removing same from the tower.

The tower contains separate systems for applying plant husbandry fluids to the plant mass in the compartments and in the central cavity. It will be understood that the term "plant husbandry fluid", or "husbandry fluid", refers to any fluid or additive which affects the growth of the plants. Examples of the husbandry fluids which may be applied to the roots include various nutrient solutions, the nutrient composition of which may be adjusted during the plants' life cycle, warm or cool water for adjusting the temperature within the tower and in the second zone foliage, through the plants taking up the water and recirculation within the plants via the plants' internal mechanisms, fluid additives for treating disease, fungi or algae, insecticides and beneficial bacteria such as nitrogen fixing bacteria.

In one form of the invention, the part of the root mass within the first zone may be treated to reduce root growth in this zone. For example, the first zone may temporarily have applied to it fluids which limit root growth by creating unfavourable growth conditions such as high or low pH, high salinity, high or low temperature or by the addition of copper hydroxide, so as to chemically 'bonzai' the roots within the compartments. Alternatively, the roots in the first zone can be starved of nutrients or moisture, while the roots in the third zone are fed to ensure growth

of the plants. The fluid application systems may also be used to sterilise the tower prior to use by flushing with a sterilising agent and to clean or remove a build up of nutrient salts from the compartments.

Figs. 2 and 3 illustrate two systems for applying nutrient solutions or other husbandry fluids to the roots within the compartments. In the first of these systems, best illustrated in Fig. 2, the side walls separating adjacent compartments contain at least one funnel 25, each of which communicates with the funnels in the compartment walls of the layers above and below to form a series of streams running vertically down the column. Associated with each funnel is a capillary 26, such as a capillary tube or a solid filament, which intersects the husbandry fluid stream and diverts a metered part of that stream into the compartment. The amount of fluid diverted can be adjusted by the size of capillary used, or the capillaries can be removed or pulled out of the stream if it is not desired to divert fluid to that compartment. The remainder of the stream passes through the funnel into the funnel below, where a further part of the stream is diverted. The fluid which is diverted to the compartment is partially taken up by the plant roots, and that part of the fluid which is not absorbed by the roots travels along the roots, enters the central cavity and flows downwards along the roots, coating central caveity roots by capillary action. Thus, fluid in this first fluid application system treats both the first and third zones. Also, the coaxial series of funnels allow the insertion of stabilising rods during shipment of the tower, the rods being removed before use.

The second fluid application system, best understood by reference to Fig. 3, is confined entirely within the first zone and involves fluid flow transverse to the direction of root growth. An optional porous capillary mat 27 extends along the bottom of the compartment and partly up the side walls of the compartment. The husbandry fluid enters a funnel-shaped aperture 28 in the top male flange 17a of the compartment and passes through a conduit 29 in the top male flange leading to an edge of the mat 27. The fluid flows through the mat and is partly absorbed by the roots lying on top of the mat. The remainder of the fluid exits the compartment via an exit conduit 30 in the bottom female flange 18b to a conduit 31 formed in foot 32. This foot is retained within the hollow top female flange 18a of the underlying compartment, with the fluid passing through an aperture 33 in that top female flange into the top male flange of the compartment diagonally below the illustrated compartment. Thus, in use, the desired fluid is introduced into the top female flanges of each of the top layer of compartments and travels down the tower in a series of stepped parallel spirals. The use of the capillary mat helps prevent occlusion of the fluid apertures by the roots and root growth into adjacent compartments.

It is possible to operate the second fluid application system to dump fluid into the central cavity part way down the tower in order to avoid contamination of lower level compartments, or to create different growth conditions in different parts of the tower. This is done by plugging the outlet path from a compartment so that the fluid is forced to exit via the root exit opening into the central cavity. A desired fluid may be introduced to the diagonally lower compartment to restart the fluid flow path.

The first and second husbandry fluid systems may be duplicated within each compartment to allow adaption of the tower for plants of differing requirements, or for applying several husbandry fluids at once. In use, the first system will be used for any fluids which are to be added to both the first and third zone, while the second system is for fluids exclusively for the first zone, such as for chemically bonzai-ing the first zone roots as described above. A further benefit of both the first and second fluid application systems is increased gaseous diffusion into the fluid due to turbulence in the fluid as it passes through the systems, leading to increased oxygenation of the fluid. The first and second fluid applications are new systems for the hydroponic and aeroponic feeding of plant roots.

Fig. 4 illustrates apparatus for a third fluid application system, for applying fluids exclusively to the roots within the central cavity 12. A reservoir 34, which may be formed by sealing the top levels of compartments or may be offset from the top of the central cavity, is fitted with a series of capillary dropper tubes 35 to form rain-like droplets which fall by gravity down through the third zone. The reservoir may be sealed and pressurized if desired. In a further modification, the fluid may be forced through a porous membrane to form a mist which descends through the third zone. The droplets or mist coat the roots at the top of the third zone by capillary action and any excess falls onto the roots below where the process is repeated.

By dividing the root mass of the plants into two zones and providing independent husbandry fluid application means for each zone, the invention allows control over

the growth, husbandry and harvesting of tower-grown plants. Further advantages of the tower arrangement are the ability to retain and treat the long-life plant mass within the first zone, which repeatedly regenerates the foliage in the second zone and roots in the third zone, for use as human or animal feed or for extraction processes and for industrial and medical properties and extracts. In addition, the ability to inhibit root growth within the compartments, the ability to open the compartments to trim the roots if necessary and the ability of the roots to grow into the third zone prevent the roots in the compartments from becoming root bound, thus extending the life of the plant and enabling many harvests of produce grown from the one long-life plant mass.

In relation to the second zone, it will be understood that the term "foliage" is used to refer to those parts of the plant normally above the ground, such as leaves, stems, flowers and fruit. Similarly, the term "root" in relation to the third zone includes the parts of the plants normally underground, including underground produce such as peanuts or potatoes.

A further advantage of the system in its preferred forms is the ability to harvest all plants very quickly by moving the tower past a fixed harvesting means such as a blade. In the case of a cylindrical tower, the tower can be rotated past the harvesting means. The roots in the central cavity can be harvested in a similar manner. Alternatively, the harvestable root mass can be harvested by applying to it a fluid, via the third fluid application system which causes this root mass to fall off, thus simplifying harvesting of this zone.

In a preferred method of growing and harvesting a plant, the plant is planted with the root crown or apex at the ramp 20 at the outer end of the compartment so that the foliage grows outwardly from the compartment through the foliage exit aperture into the second zone and the root mass grows inwardly, through the root anchors 23 and the root exit aperture 21 into the central cavity. When the plant reaches the desired level of maturity, the foliage is harvested, with the roots within both the compartment and the central cavity being retained to prevent partial root death in the first zone during the development of new foliage growth from the apex of the root. The roots in both zones are fed with nutrient solutions, for example by the first fluid application system, or the second and third systems in combination. The combined root mass in the two zones minimises damage and shock to the plant and encourages more rapid re-establishment of the second zone foliage. After the initial establishment of the second zone foliage the third zone roots may be harvested, or maintained in order to maximise foliage growth in the second zone. Harvesting the third zone root mass forces the plant toward early leaf development to achieve photosynthesis for food.

Fig. 5 shows a plan view of a multiple compartment panel, with the top cut away. In this modification, the compartments operate in substantially the same way as that of Figs. 2 and 3, and like numerals are used to illustrate like parts. The significant difference is that in Fig. 5 a number of compartments are formed together in a panel, separated by dividing walls 36 depending from the top section, thus eliminating the need for interengaging male and female flanges between every compartment and its neighbours. Instead, the male 17 and female 18 flanges are required only at the

end compartments. The flanges may have recesses 48 at their inner ends to allow attachment to structural members in the tower. The transverse fluid application system is also simplified, as the fluid may flow through a mat which extends across all compartments in the panel and thus apertures are required only in the male and female flanges at the edges of each panel.

Fig. 6 is a schematic perspective of an alternative embodiment, in which the apparatus is constructed as a wall. The operation of the apparatus is essentially the same as that described above for Figs. 1 to 5, except that the third zone is the region behind the wall instead of a central cavity. If desired, two such walls can be situated back to back with a space between which acts as a common third husbandry zone.

Fig. 7 shows a multiple compartment panel for use in the wall of Fig. 6. The panel is essentially the same in operation as that of Fig. 5, and like reference numerals are used to denote like parts. The taper of the compartments is retained by the inclusion of wedge-shaped dividing walls 36 between adjacent compartments.

Fig. 7A is a variation on the tray of Fig. 7, in which the orientation of the compartments is alternated so that foliage grows from both sides of the wall. The third zone roots grow outwardly from the foliage-remote end of each compartment. Preferably, the roots are enclosed in flexible covers 46 extending down the wall to facilitate the application of husbandry fluids to the third zone root mass. As shown, the first fluid application system may have any number of funnels 25 disposed in the dividing walls 36. If more than one funnel is used, the capillaries

may lead from the fluid streams defined by the funnels to a common reservoir formed as a moat surrounding the funnels and then enter the compartments through a single inlet.

Figs. 8 and 9 illustrate an alternative structure according to preferred embodiment of the invention. The structure is formed from 2 sheets of flexible material, such as plastic, which are sealed together by bonding or welding over part of their surfaces. The structure is then hung from an upright frame. The spaces between the 2 sheets at the parts which are not sealed form conduits for the flow of liquid and pockets 37 to serve as compartments which form the first husbandry zone. The compartments may have a capillary mat, and insertable root anchors to provide at least partial root stability.

As shown in Fig. 8, the sheets define a lower fluid reservoir 38, a conduit 39 for passage of fluid to the top and a series of conduits 40 leading to the compartments formed in rows between the sheets. If desired, any of the conduits can be closed off by clamping of the flexible sheets. Where a very large number of plants are to be grown, this may be done in a number of panels and it may be more economical to close off conduit 39 and provide common external piping.

Referring to Fig. 9, it will be seen that the compartments are formed as pockets 37 into which a pair of opposed, brush-like, root anchors 41 are inserted to provide plant stability. These compartments form the first plant husbandry zone, with the foliage extending outwardly through an opening 42 in the front sheet 43 and harvestable roots extending from the bottom of the compartment through a hole in

the rear sheet 44. Ties may be used to give additional stability to the foliage which may be necessitated by the flexibility of the structure.

Fig. 10 illustrates a variation of the flexible construction of Figs. 8 and 9, in which the structure may be formed from a single sheet 45 of flexible material. The sheet folded to form a series of parallel Ω-shaped channels extending down the sheet. The backs of these channels are closed by welding or adhesive tape, and the channels are closed periodically along their length to form a series of pockets 37 with foliage exit openings in the sheet near their tops. The root exit hole may be formed either in the tape, thus forming the third zone at the rear of the sheet, or in the side of the pocket, forming the third zone alongside the foliage zone. In the latter case, the roots may be covered as described with reference to Fig. 7A.

The first husbandry fluid application may be formed by vertical tubes running parallel to each vertical row of pockets and having metering capillaries extending into each pocket. The fluid flows along the roots and onto the the roots third zone, as previously described in relation to other embodiments of the invention.

The second husbandry fluid application system consists of a compressible tube 47 which extends down the rear of each vertical row of pockets, for transferring fluid down each row, transversely to the root growth.

A 3 sheet configuration can also be formed, with compartments formed between each outer sheet and the inner sheet with the air roots extending through

openings in the both the inner sheet and the rear sheet adjacent the rear of the pocket. In a further variation, staggered columns of hexagonal compartments may be formed between the sheets to provide an increased number of compartments for a given surface area.

While particular embodiments of this invention have been described, it will be evident to those skilled in the art that the present invention may be embodied in other specific forms without departing from the essential characteristics thereof. The present embodiments and examples are therefore to be considered in all respects as illustrative and not restrictive, and all modifications which would be obvious to those skilled in the art are therefore intended to be embraced therein.

CLAIMS

1. A plant growing apparatus adapted for control of the growth, feeding, treatment and environment of and the simultaneuous husbandry of a plurality of plants, comprising an upright structure which defines three plant husbandry zones into which each plant is divided:

a first plant husbandry zone for providing stability and control of a long-life plant mass of said plants, comprising an upright array of compartments each adapted to contain the long-life plant mass of a plant, said compartments allowing access to the plant mass therein,

a second plant husbandry zone located externally to said compartments for the growth and husbandry of harvestable foliage communicating with the long-life plant mass; and

a third plant husbandry zone located externally to said compartments for the growth and husbandry of harvestable root mass communicating with the long-life plant mass; and

means for applying plant husbandry fluids to the plant mass in at least the first zone;

the apparatus allowing harvesting of the harvestable foliage and harvestable root mass of the plants and regeneration of harvestable foliage and root mass in the second and third zones from the long-life plant mass.

2. Apparatus according to claim 1 wherein the first

zone comprises a vertical and horizontal array of said compartments.

3. Apparatus according to claim 1 wherein the second and third zones are remote from each other and communicate through the first zone.

4. Apparatus according to claim 2 wherein the upright structure includes a wall containing the compartments.

5. Apparatus according to claim 4 wherein the first zone is within the wall and the second and third zones extend away from opposite sides of the wall.

6. Apparatus according to claim 1 wherein said compartments are elongated in a direction extending from a first end communicating with the second zone to a second end communicating with the third zone.

7. Apparatus according to claim 6 wherein said compartments are tapered inwardly from said first end to said second end.

8. Apparatus according to claim 4 wherein the wall is a wall of a tower structure, said third zone comprises a central cavity extending along the longitudinal axis of the tower and said compartments extend substantially radially outwardly from said third zone to the second zone.

9. Apparatus according to claim 1 wherein said means for applying fluid to the first zone plant mass includes a plurality of vertically displaced funnels in fluid communication to form a vertical stream of fluid flowing down the apparatus, and capillary means extending between said stream and a compartment for

diverting a metered part of the fluid to said compartment.

10. Apparatus according to claim 9 wherein a part of said diverted fluid flows along the first zone plant mass into the third zone.

11. Apparatus according to claim 10 wherein the diverted fluid coats the first zone plant mass and flows therealong and into the third zone.

12. Apparatus according to claim 1 wherein said means for applying fluid to the first root zone includes transverse flow means for causing flow of fluid transverse to root growth.

13. Apparatus according to claim 12 wherein said transverse fluid flow passes through a porous mat in contact with the roots.

14. Apparatus according to claim 12 wherein said transverse flow means includes means for transferring excess fluid to a lower compartment in said first zone.

15. Apparatus according to claim 1 further comprising means for providing plant husbandry fluid to the third zone.

16. Apparatus according to claim 15 wherein said means for applying fluid to the third zone includes means for introducing droplets to the top of the third zone.

17. Apparatus according to claim 15 wherein said means for applying fluid to the third zone includes means for introducing mist to the top of the third

zone.

18. Apparatus according to claim 15 wherein the means for applying fluid to the third zone is adapted to coat upper roots within the third zone with the fluid and to cause excess fluid to drip from the upper roots to lower roots in the third zone.

19. Apparatus according to claim 1 wherein the compartments have root anchor structures comprising a plurality of spaced members for retaining the roots therebetween.

20. Apparatus according to claim 19 wherein the members comprise a plurality of fingers extending transversely to the compartment.

21. Apparatus according to claim 1 wherein said compartments may be removed from the tower and opened for access to exposed roots in the first zone.

22. Apparatus according to claim 4 wherein the wall is constructed by stacking layers of the compartments.

23. Apparatus according to claim 22 wherein adjacent compartments within each layer are interengaged by means of interengaging flanges.

24. Apparatus according to claim 1 wherein the structure comprises at least two parallel sheets of flexible material sealed together over part of their surfaces, with the compartments being located in pockets between the sheets.

25. Apparatus according to claim 24 wherein root anchor means are insertable in the pockets.

26. Apparatus according to claim 24 wherein further spaces between the sheets form conduits for the supply of plant husbandry fluid to the compartments.

27. A process for the simultaneous growth and husbandry of a plurality of plants, comprising:

growing a long-life root mass of a plurality of plants in an upright array of compartments defining a first plant husbandry zone, each compartment providing at least partial stability and access to an exposed portion of the long-life plant mass therein,

applying plant husbandry fluid to the compartments,

growing harvestable foliage of said plants outwardly from the compartments in a second plant husbandry zone,

growing a foliage-remote harvestable end of the root mass in a third plant husbandry zone,

harvesting the foliage in the second zone and/or the root mass in the third zone while retaining the long-life plant mass in the compartments, and

allowing regeneration of the harvestable foliage and/or the harvestable root mass from the long-life plant mass.

28. A process according to claim 27 comprising the step of removing at least part of the harvestable root mass after allowing at least partial regrowth of the foliage.

29. A process according to claim 27 wherein said harvesting step comprises moving a tower comprising

said array past a harvesting means.

30. A process according to claim 29 wherein the tower is rotated past the harvesting means.

31. A process according to claim 27 further comprising applying a root growth inhibiting substance to part of the root mass.

32. A process according to claim 31 wherein the root growth inhibiting substance is applied to the long-life root mass in the compartments.

33. A process according to claim 27 wherein the long-life plant mass within the compartments is fed hydroponically.

34. A process according to claim 27 wherein the harvestable root mass comprises roots are suspended in air.

35. A process according to claim 34 wherein plant husbandry fluid is applied to the harvestable root mass by allowing the fluid to travel along the root mass from the first zone to the third zone.

36. A process according to claim 34 wherein plant husbandry fluid is applied to the harvestable root mass by introducing droplets or mist of the fluid to the top of the third zone and allowing the droplets to fall onto the harvestable root mass.

37. A process according to claim 34 wherein the plant husbandry fluid coats the harvestable root mass by capillary action.

38. A process according to claim 27 comprising at

least partially stabilising the plants by root anchor structures comprising a plurality of spaced members between which the roots are retained.

5

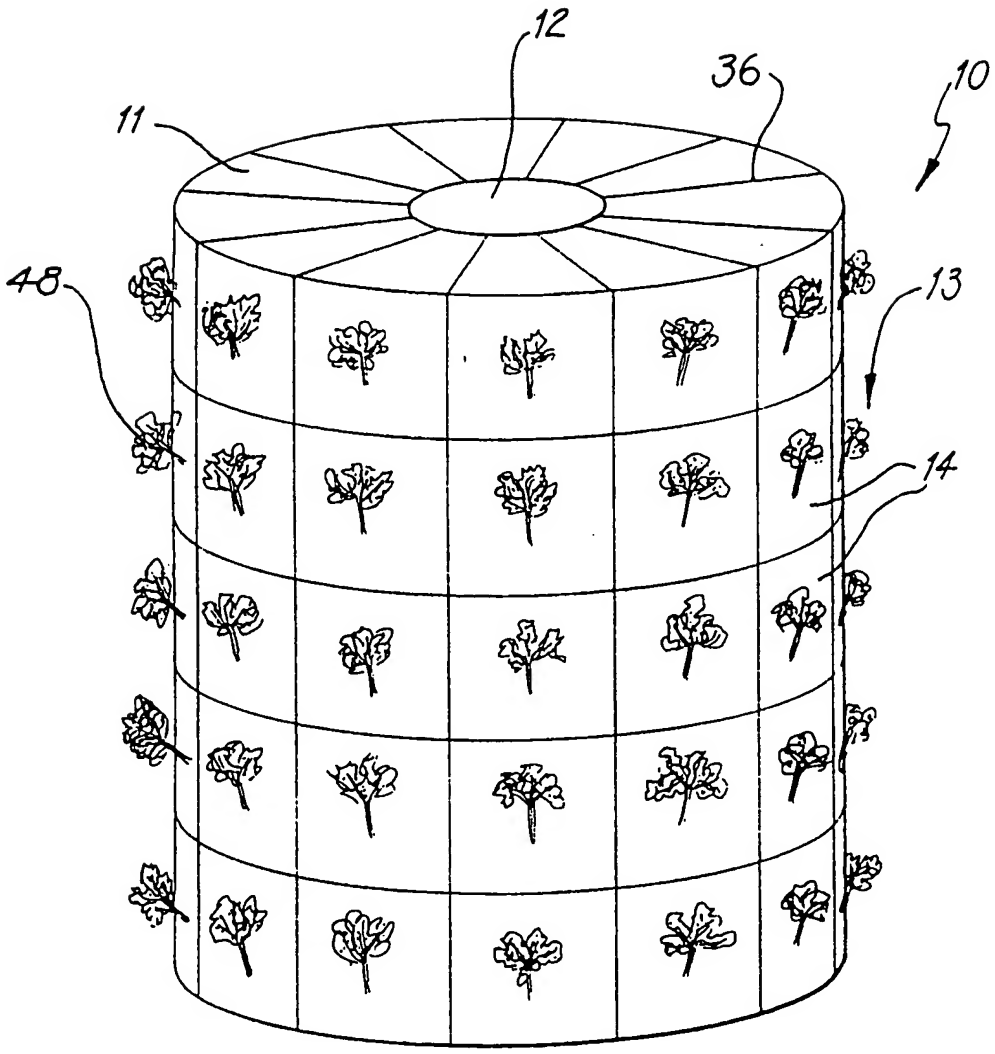


FIG. 1

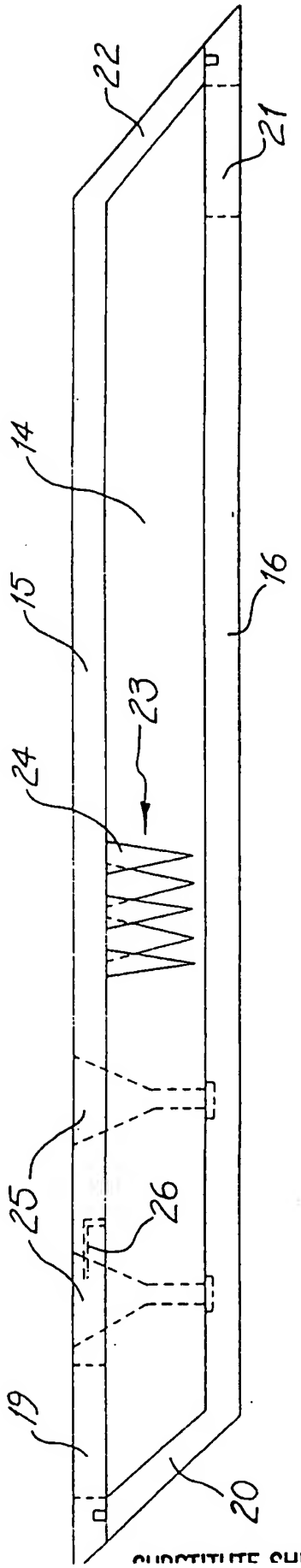


FIG. 2

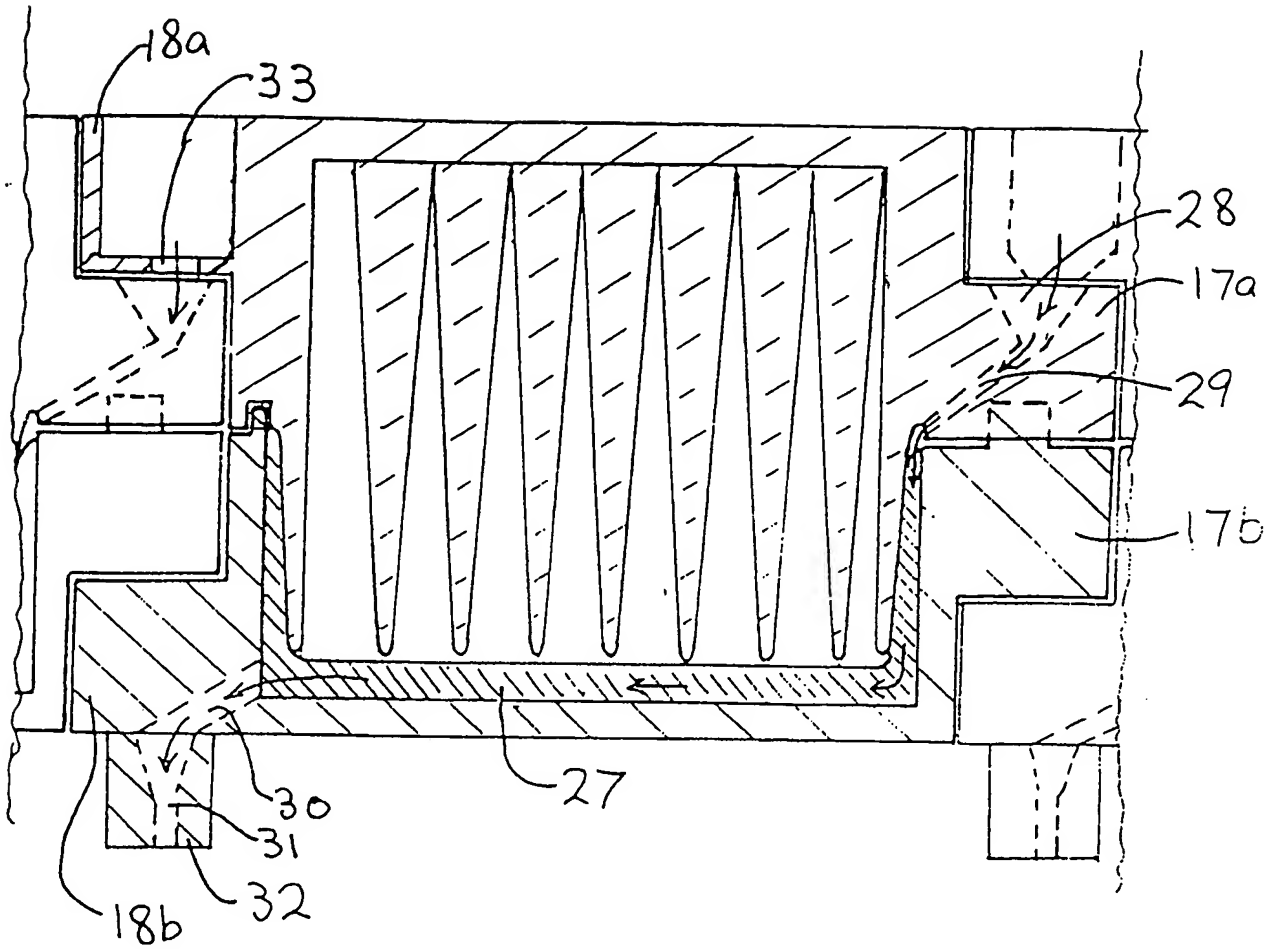


Fig 3

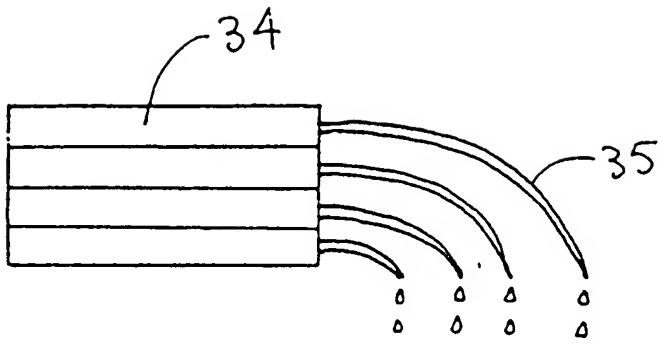


Fig. 4

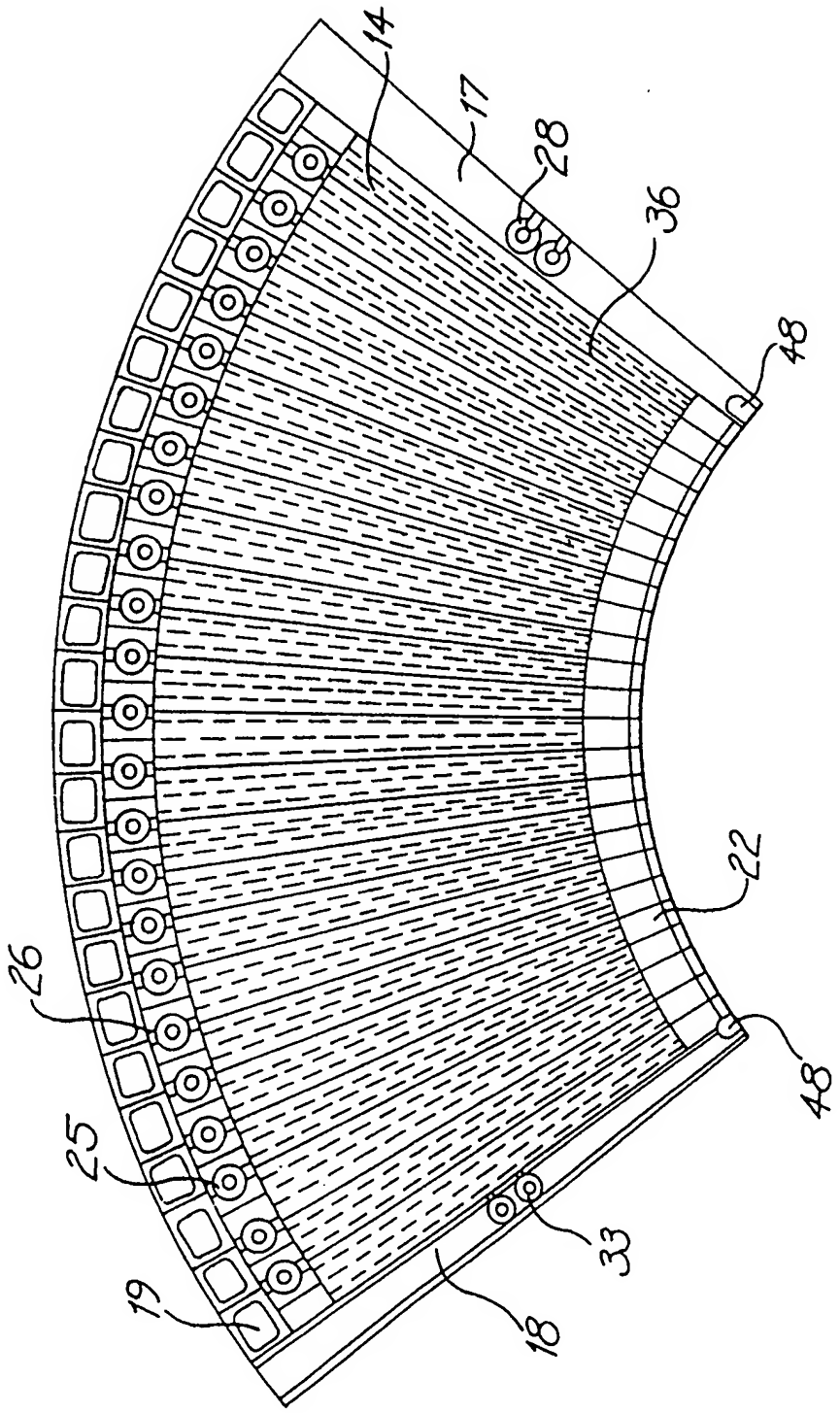


FIG. 5

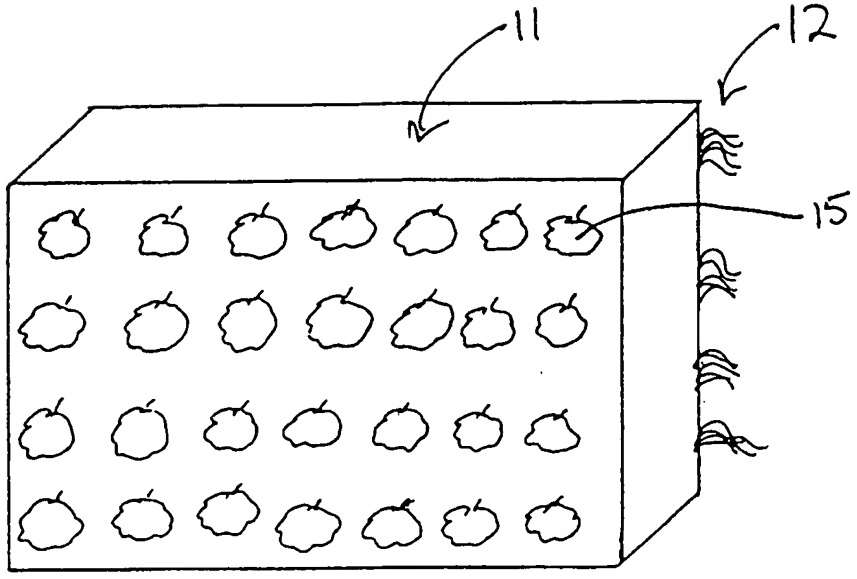


Fig. 6

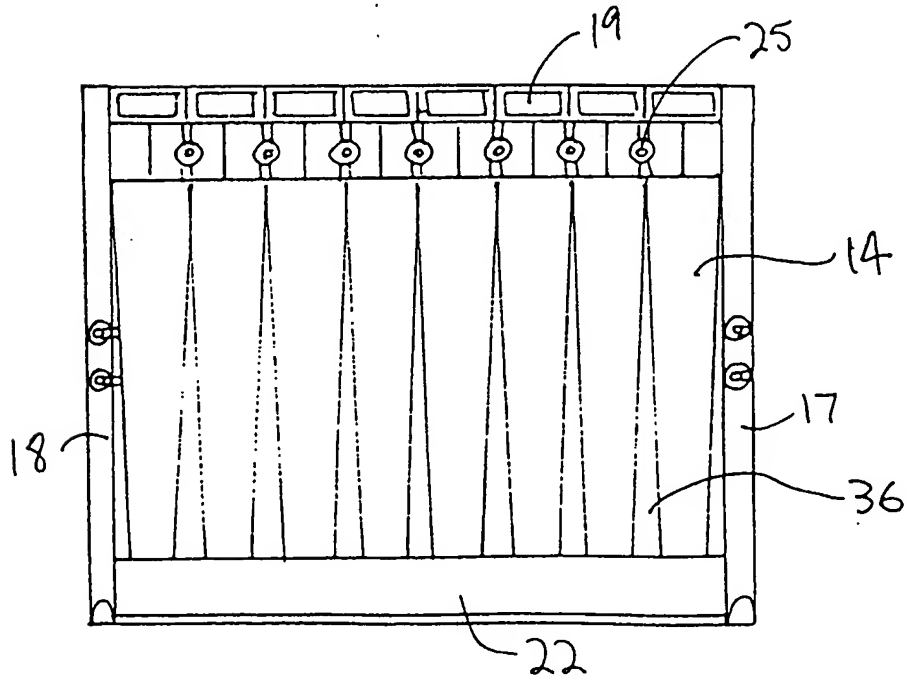


Fig 7

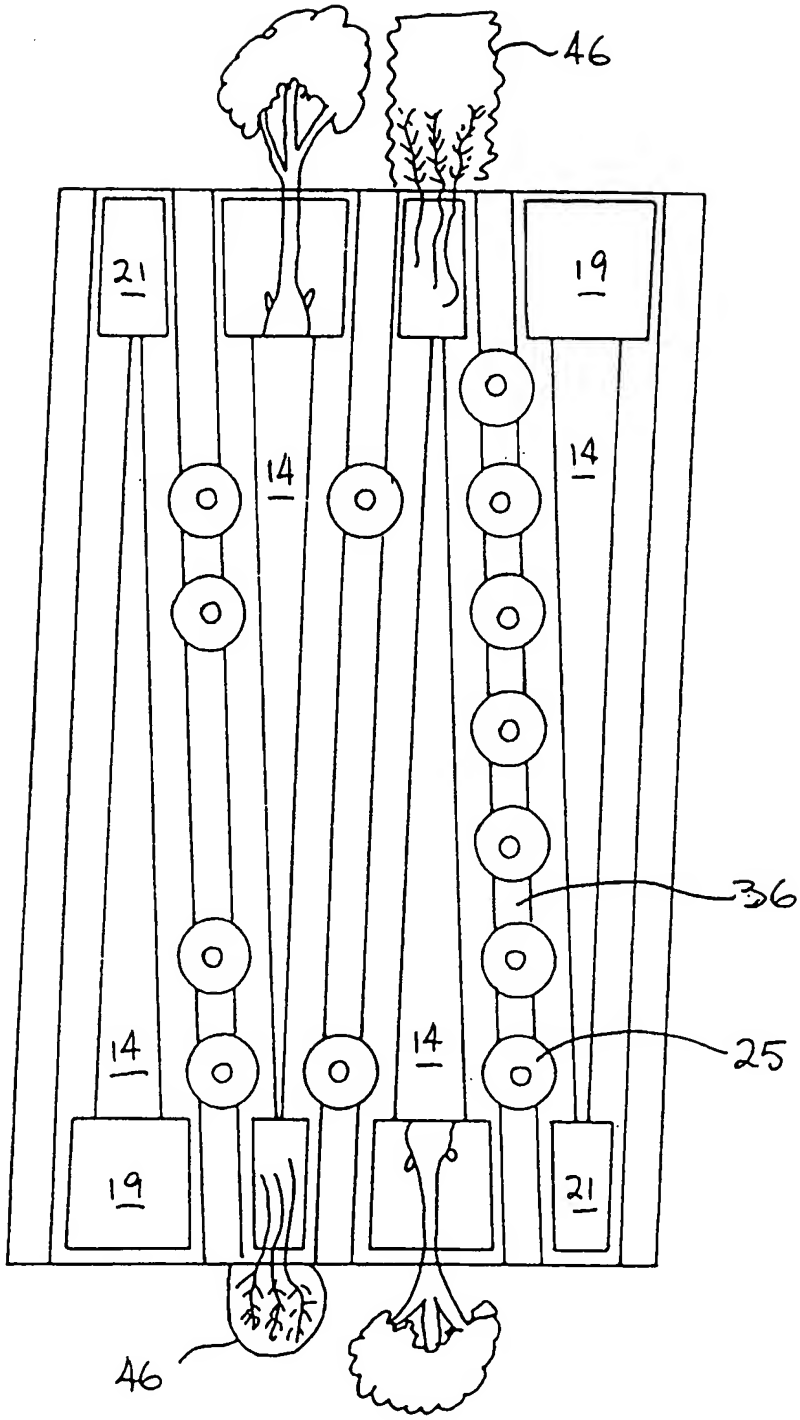


Fig. 7A

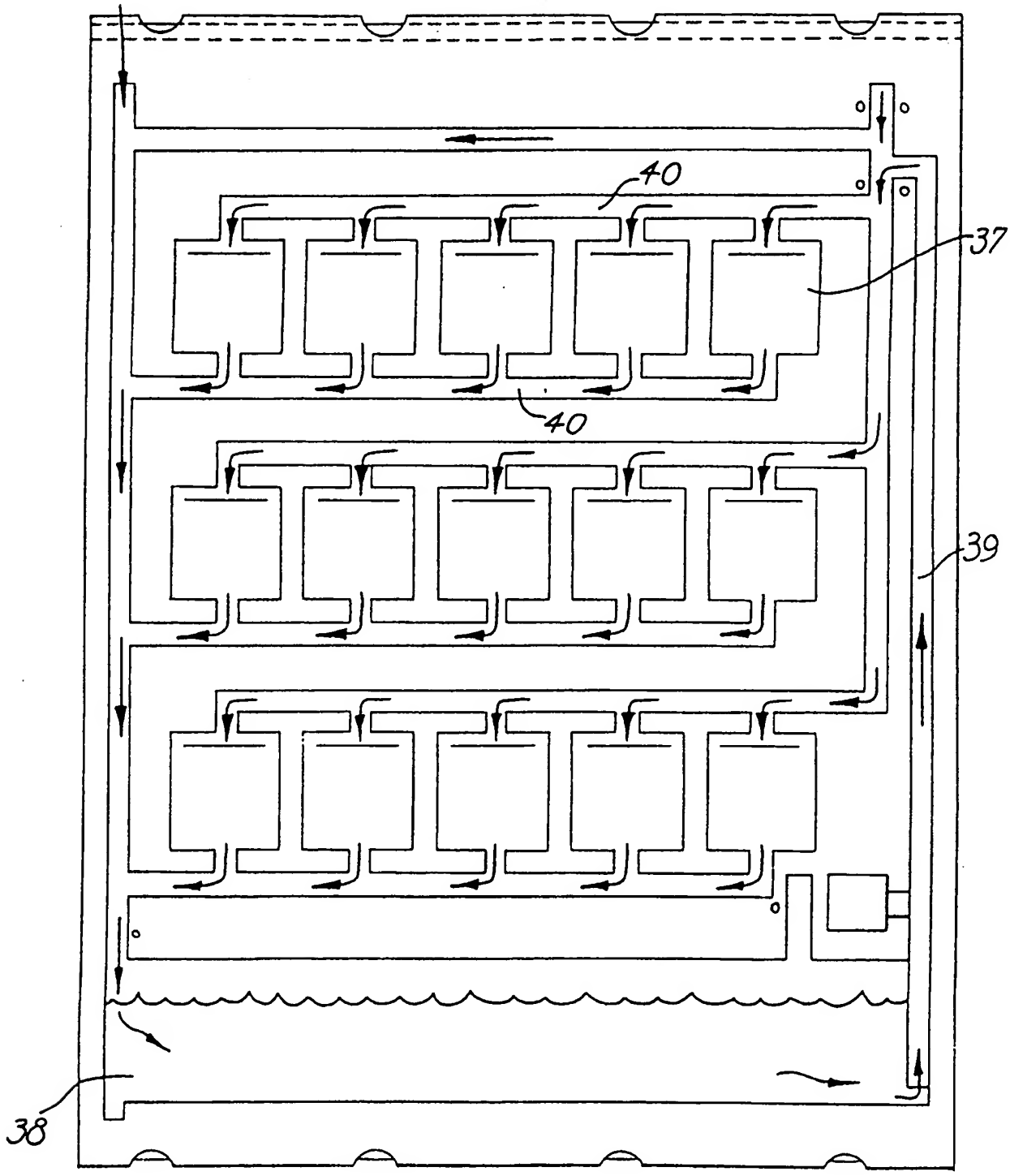


FIG. 8

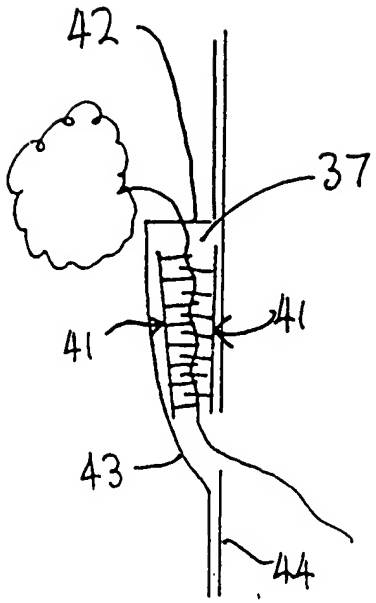


Fig. 9

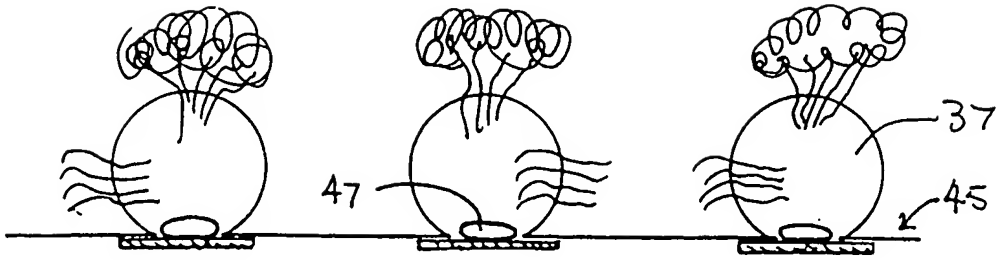


Fig 10

A. **CLASSIFICATION OF SUBJECT MATTER**

Int. Cl.[5] A01G 9/02, 31/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. **FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC: A01G 9/02, 31/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

AU: IPC as above

Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)

C. **DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	AU,B,43029/72 (459656) (G.K. TODD) 2 December 1973 (02.12.73) figures 1 and 2	1-38
A	CA,A,1043106 (VESTERGAARD BENT) 28 November 1978 (28.11.78) figures 1-3	1-38
A	EP,A,301362 (AGRIFUTURA S.r.l.) 1 February 1989 (01.02.89) figures 1-3	1-38
A	GB,A,1486553 (M. HOWGILL) 21 September 1977 (21.09.77) figures 1-3	1-38

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 March 1994 (17.03.94)	5 April 1994 (05.04.94)

Name and mailing address of the ISA/AU

AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION
PO BOX 200
WODEN ACT 2606
AUSTRALIA

Facsimile No. (06) 2853929

Authorized officer

G.M. COX

Telephone No. (06) 2832484

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
A	GB,A,2055281 (HAGO PRODUCTS LIMITED) 4 March 1981 (04.03.81) figures 1-5	1-38
A	DE,A,3307428 (JURGENS THEODOR) 3 March 1983 (03.03.83) figures 1-4	1-38
A	CH,A,665529 (JAMES MAILLEFER) 31 May 1988 (31.05.88) figures 1-3	1-38
A	AU,A,29093/77 (GOODDALL LTD.) 5 April 1978 (05.04.78) figure 1	1-38
A	AU,B,54343/80 (533897) (REGENCY INVESTMENTS LTD.) 9 July 1981 (09.07.81) figure 5	1-38
A	AU,B,71971/81 (539814) (BONAR HORTICULTURE LTD.) 7 January 1982 (07.01.82) figure 2	1-38
A	AU,A,13612/92 (M-HYDROPONICS RESEARCH CO. LTD.) 17 September 1992 (17.09.92) figure 1	1-38
A	AU,A,70073/91 (ISOVER SAINT-GOBAIN) 1 August 1991 (01.08.91) figures 1-4	1-38
A	AU,B,58098/90 (639933) (BENTLE PRODUCTS AG) 3 January 1991 (03.01.91) figure 1	1-38

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member					
AU 13612/92	JP	4330175	CA	2082278	EP	533939
	NO	924272	WO	92/15194		
AU 43029/72						
DE 3307428						
CH 665529	US	5172516	AU	50589/85	CA	1289745
	CH	660665	DK	5504/85	EP	183653
	ES	296905	JP	61192229	US	4667439
	ZA	8509156				
GB 2055281						
EP 301362	IT	1213664	JP	1104117	JP	5011922
GB 1486553						
AU 58098/90	DD	300067	DK	1607/90	EP	406458
	ES	2042456	HU	59530	PT	94581
AU 70073/91	AT	99113	EP	440524	FR	2657497
	JP	4211312	PT	96605	US	5287651
AU 71971/81	AR	228866	BR	8103899	CA	1164213
	DK	2695/81	EP	42697	ES	265331
	GB	2078072	GR	74507	IL	63127
	IN	155349	JP	57065135	NZ	197478
	PT	73219	US	4392327	ZA	8104155
AU 54343/80						
AU 29093/77	BE	859015	FI	772798	SE	7710735

END OF ANNEX